

WHAT IS CLAIMED IS:

1                   1.       A remote copy system, comprising:  
2                   first and second primary storage subsystems, the first primary storage  
3 subsystem including a first primary volume, the second primary storage subsystem including  
4 a second primary volume, the first and second primary volumes storing a plurality of write  
5 data in a given order;  
6                   an intermediate storage subsystem configured to receive the write data from  
7 the first and second primary storage subsystems, the intermediate storage subsystem  
8 including a write-order-information provider that is configured to generate write-order  
9 information for the write data received from the first and second primary storage subsystems,  
10 the write order information being associated with the write data received from the first and  
11 second primary storage subsystems, the write order information reflecting the given order of  
12 storage of the write data in the first and second primary storage subsystems; and  
13                   first and second secondary storage subsystems configured to receive the write  
14 data from the intermediate storage subsystem, the first secondary storage subsystem including  
15 a first secondary volume that is configured to mirror the first primary volume, the second  
16 secondary storage subsystem including a second secondary volume that is configured to  
17 mirror the second primary volume, wherein the write data are stored in the first and second  
18 secondary storage subsystems according to the write order information associated with the  
19 write data.

1                   2.       The remote copy system of claim 1, wherein the write data are send to  
2 the intermediate subsystem from the primary subsystems using a synchronous remote copy  
3 method, and the write data are send to the secondary subsystems from the intermediate  
4 subsystem using an asynchronous remote copy method.

1                   3.       The remote copy system of claim 1, wherein the write-order-  
2 information provider is a counter that generates a sequence number to be attached to the write  
3 data received from the primary subsystems.

1                   4.       The remote copy system of claim 3, wherein the intermediate  
2 subsystem includes first and second intermediate volumes, the first intermediate volume  
3 being configured to receive the write data from the first primary volume, the second

4 intermediate volume being configured to receive the write data from the second primary  
5 volume.

1 5. The remote copy system of claim 4, further comprising:  
2 a valid counter provided in the intermediate subsystem, the valid counter being  
3 configured to keep the highest sequence number of the write data that is ready to be validated  
4 for copying at the secondary subsystems.

1 6. The remote copy system of claim 4, further comprising:  
2 first and second primary bitmaps provided at the first and second primary  
3 subsystems, respectively;  
4 first and second intermediate bitmaps provided at the intermediate subsystem;  
5 and  
6 first and second secondary bitmaps provided at the first and second secondary  
7 subsystems, respectively,  
8 wherein the first and second primary bitmaps are associated with the first  
9 intermediate bitmap and the first and second secondary bitmaps are associated with the  
10 second intermediate bitmap,  
11 wherein the bitmaps are used during a resynchronization process to determine  
12 and copy only data have been changed since suspension of mirroring of a paired volumes.

1 7. The remote copy system of claim 3, wherein the intermediate  
2 subsystem including a journal volume to receive the write data from the first and second  
3 primary subsystems.

1 8. The remote copy system of claim 1, wherein the first and second  
2 primary subsystems are disk array units.

1 9 The remote copy system of claim 1, wherein the primary subsystems  
2 are provided at a primary site and the secondary subsystems are provided at a secondary site,  
3 the primary site including a primary host, the secondary site including a secondary host,  
4 wherein the secondary subsystems are configured to replace the primary  
5 subsystems as primary storage areas if either the primary subsystems or the primary host  
6 experiences failure or is taken off line.

1                   10.     An intermediate storage subsystem provided in a remote copy system  
2     and coupled to a plurality of primary storage subsystems and a plurality of secondary  
3     subsystems, the intermediate storage subsystem comprising:

4                   a first storage area configured to receive write data from at least one primary  
5     subsystem, the write data being received synchronously from the at least one primary  
6     subsystem; and

7                   a write-order-information provider configured to generate write order  
8     information for the write data received from the at least one primary subsystem, the write  
9     order information being associated with the write data,

10                  wherein the write order information is used to store the write data in at least  
11     one of the secondary subsystems, so that the at least one secondary subsystem mirrors the at  
12     least one primary subsystem.

1                   11.     The storage subsystem of claim 10, wherein the first storage area is  
2     configured to receive first and second write data from the at least one primary subsystem in a  
3     given order, the first and second write data being provided with first and second write order  
4     information, respectively, by the intermediate subsystem,

5                   wherein the first and second write data are stored in the at least one secondary  
6     subsystem according to the given order using the first and second write order information.

1                   12.     The storage subsystem of claim 10, wherein the write-order-  
2     information provides is a counter configured to generate sequence numbers, the generated  
3     sequence numbers being associated with the write data according to an order the write data  
4     are received from the at least one primary subsystem.

1                   13.     The storage subsystem of claim 10, wherein the first storage area is a  
2     journal volume that is configured to receive write data from the plurality of primary  
3     subsystems.

1                   14.     The storage subsystem of claim 10, further comprising:  
2                   a second storage area,

3                   wherein the plurality of primary subsystems including a first primary volume  
4     provided in a first primary subsystem, and a second primary volume provided in a second  
5     primary subsystem.

6 wherein the first and second storage areas are first and second intermediate  
7 volumes, the first intermediate volume being configured to receive write data from the first  
8 primary volume and the second intermediate volume being configured to receive write data  
9 from the second primary volume,

10 wherein the first intermediate volume is configured to send the write data  
11 received from the first primary volume to a first secondary volume provided in a first  
12 secondary subsystem and the second intermediate volume is configured to send the write data  
13 received from the second primary volume to a second secondary volume provided in a second  
14 secondary subsystem.

1 15. The storage subsystem of claim 14, further comprising:  
2 a valid counter provided in the intermediate subsystem, the valid counter being  
3 configured to keep the highest sequence number of the write data that is ready to be validated  
4 for copying at the secondary subsystems.

1 16. The storage subsystem of claim 14, further comprising:  
2 first and second primary bitmaps provided at the first and second primary  
3 subsystems, respectively;  
4 first and second intermediate bitmaps provided at the intermediate subsystem;  
5 and

6 first and second secondary bitmaps provided at the first and second secondary  
7 subsystems, respectively,

8 wherein the first and second primary bitmaps are associated with the first  
9 intermediate bitmap and the first and second secondary bitmaps are associated with the  
10 second intermediate bitmap,

11 wherein the bitmaps are used during a resynchronization process to determine  
12 and copy only data have been changed since suspension of mirroring of a paired volumes.

1 17. The storage subsystem of claim 16, wherein the first and second  
2 secondary volumes are configured to mirror the first and second primary volumes,  
3 respectively,

4 wherein the write data are received from the primary subsystems at the  
5 intermediate subsystem synchronously,

6 wherein the write data are transmitted to the secondary subsystem from the  
7 intermediate subsystem asynchronously.

1                   18.     The storage subsystem of claim 10, wherein the intermediate storage  
2 subsystem is a disk array unit.

1                   19.     A method for operating a remote copy system, the method comprising:  
2                   receiving first write data from a first primary storage subsystem at an  
3 intermediate storage subsystem, the first write data being sent by the first primary subsystem  
4 synchronously;  
5                   associating first write order information to the first write data;  
6                   receiving second write data from a second primary storage subsystem at the  
7 intermediate subsystem, the second write data being sent by the second primary subsystem  
8 synchronously;  
9                   associating second write order information to the second write data;  
10                  transmitting asynchronously the first write data and the first write order  
11 information to a first secondary storage subsystem; and  
12                  transmitting asynchronously the second write data and the second write order  
13 information to a second secondary storage subsystem,  
14                  wherein the first and second write data are stored in the first and second  
15 secondary subsystems, respectively, according to the first and second write order information.

1                   20.     The method of claim 19, further comprising:  
2                   receiving synchronously third write data from the first primary subsystem at  
3 the intermediate storage subsystem, the third write data being received at the intermediate  
4 subsystem after the first write data;  
5                   associating the third write data with third write order information;  
6                   transmitting asynchronously the third write data and the third write order  
7 information to the first secondary subsystem,  
8                   wherein the first and third write data have the same destination address, the  
9 destination address identifying a storage area in the first secondary subsystem,  
10                  wherein the first and third write order information is used to store the first  
11 write data to the identified storage area prior to storing the third write data to the identified  
12 storage area.

1                   21.     The method of claim 19, wherein the write order information is  
2 sequence numbers, the method further comprising:

transmitting a request to prepare the first, second, and third write data for storage in the first and second secondary subsystems, the prepare request being transmitted to the first and second secondary subsystems from the intermediate subsystem, the prepare request including a reference sequence number; and

transmitting a request to validate the write data that have been prepared according to the prepare request, the validate request being transmitted to the first and second secondary subsystem from the intermediate subsystem that identifies the write data to be prepared.

22. A computer readable medium comprising a computer program for operating a remote copy system, the computer program comprising:

- code receiving first write data from a first primary volume of a first primary storage subsystem at an intermediate storage subsystem, the first write data being sent synchronously by the first primary subsystem;
- code for associating first write order information to the first write data;
- code for receiving second write data from a second primary volume of a second primary storage subsystem at the intermediate subsystem, the second write data being sent synchronously by the second primary subsystem;
- code for associating second write order information to the second write data;
- code for transmitting asynchronously the first write data and the first write order information to a first secondary storage subsystem, the first secondary subsystem including a first secondary volume; and
- code for transmitting asynchronously the second write data and the second write order information to a second secondary storage subsystem, the second secondary subsystem including a second secondary volume,

wherein the first and second write data are stored in the first and second secondary subsystems, respectively, according to the first and second write order information, so that the first and second secondary volumes mirror the first and second primary volumes.

23. An intermediate storage subsystem provided in a distributed remote copy system, the intermediate storage subsystem comprising:

- means for receiving write data from first and second primary volumes of first and second primary subsystems, the first primary volume being defined in the first primary

5 subsystem, the second primary volume being defined in the second primary subsystem, the  
6 write data being received synchronously from the primary subsystems; and  
7 means for generating write order information for the write data received from  
8 the primary subsystems, the write order information being associated with the write data, the  
9 write order information providing information as to a write order of the write data,  
10 wherein the write order information is used to store the write data in the first  
11 and second secondary volumes of first and second secondary subsystems, the first secondary  
12 volume being defined in the first secondary subsystem, the second secondary volume being  
13 defined in the second secondary subsystem,  
14 wherein the first and second secondary volumes mirror the first and second  
15 primary volumes.